IOP Institute of Physics
Nonlinear and Complex Physics Group

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Fig. 1: Engaging the crowd. Complexity emerges from crowd behaviour. Courtesy of BICS, University of Bath.

Contents

1. Chair's welcome
2. Featured article: Complexity and the social sciences
3. Reports from previous events
4. Forthcoming events supported by the NCPG
5. Items of interest
6. Group committee
7. Contributions to the newsletter

http://www.iop.org/activity/groups/subject/Nonlinear_and_Complex_Physics/index.html

1. Chair’s Welcome

Welcome to this second newsletter for our rapidly growing Nonlinear and Complex Physics Group. Our membership has increased by approximately 50% in the past year so that we now have more than 110 members. Thank you all for your tremendous support. As you can see from the Newsletter we have already had a highly successful meeting on Nonlinear and Complex Phenomena in Bath where the focus was primarily on research in Biology and Physics. Further meetings under our umbrella are planned on **'Applied Complexity' in Cambridge in September** and we are also supporting sessions on **'Nonlinearity' at CMMP in Warwick**. A further special 'Christmas' lecture is at the planning stage and details will be announced soon. This is your group and I would like to encourage you to send us suggestions for topics and meetings which which are of interest to you. We are keen to support the interests of the membership and you should feel free to contact myself or any other committee member. I am sure that you will enjoy the stimulating article by Jean Boulton and I also encourage members to submit equally thought provoking articles for publication in future issues.

So, come and join us now at http://www.iop.org/activity/groups/subject/Nonlinear_and_Complex_Physics/index.html.

Tom Mullin, Chair (NCPG)

2. Featured article: Complexity and the social sciences

by Jean Boulton

Stretching physics into social sciences has a long history. For example, the Marquise de Chatelet translated Newton’s Principia into French and this resulted in Voltaire, her lover, publishing ‘Éléments de la philosophie de Newton’ in 1738 (Bodanis, 2006). This was credited as the driving force behind the French Enlightenment’s faith in reason and in grand design. It was assumed that the analytical method of Newtonian physics applied to the entire field of thought and knowledge. As economist Hayek says (1958):

‘*it has been the rationalist, plausible, and apparently logical argument of the French tradition, with its flattering assumptions about the unlimited powers of human reason, which has progressively gained influence’.*

The next physics theory to be commandeered was equilibrium thermodynamics, which formed the basis for economic analysis. Leon Walras (1874), in ‘Elements of Pure Economics’, as he developed general equilibrium theory, said ‘*…this pure theory of economics is a science which resembles the physico-mathematical sciences **in every respect’**.* Notwithstanding the best efforts of economist Thorstein Veblen (1898), who plaintively asserted that there was no reason to assume economic systems reached equilibrium, no reason to assume Man was rational in his choices, no reason to assume the economy could be understood in terms of simple cause-and-effect relationships, such methods still prevail. This is despite the fact that many writers have pointed out that it is not automatically make it scientific to adopt a scientific theory for purposes other than that for what it was intended. As economist Fulbrook (2008) says, writing of the classical economist Leon Walras:

*‘What matters to… Walras is not the methodological fit but rather the method itself…..instead of being led by ontological inquiry [*ie starting with the real-life situation*], he defines a priori the ontology to fit the method* [ie asserts that the classical physics view is valid*]. Nothing could have been more against the procedures and mindset that have dominated the natural*

sciences from Copernicus on [ie science itself would never work in this way*]'*

So what about complexity theory? Does complexity theory have something to offer social sciences or is there a risk of introjecting yet another physics theory and getting beguiled by it? There are certainly examples of worrying practices. For example, some early modelling work undertaken at the Sante Fe Institute (Waldrop, 1992) showed a phase change in a cellular automata modelling problem. This 'edge of chaos' has entranced many social scientists. It has been taken to imply that organisations should try to emulate such an 'edge' between order and chaos as it has creative potential and thus will lead to success. More complex modelling would reveal a landscape of many more complex features than a simple, single phase change, but this 'edge of chaos' has stuck (for example, Brown and Eisenhardt, 1998).

Another example that has caught the imagination of social scientists is the butterfly flapping its wings in chaos theory. The deterministic chaos of chaos theory is often conflated with the ordinary, normal variety of random chaos which, for example, Prigogine (1984) is referring to in his discussions about self-organisation and dissipative structures in his book 'Order out of Chaos'. Arguably, sensitivity to initial conditions is likely to be smoothed out in human complex systems such as organisations or economies, where qualities and characteristics vary across the piece: where there is learning, instabilities and shifts in the external environment: diversity and historicity. For these reasons, parameters in differential equations rarely capture the complexity of humans and their behaviour and, equally, cannot easily represent the process of development and change. However the butterfly is used to point to the importance of specific, small events and creates a sort of heroism around the action or person who is credited with this vital initiation. Deeper considerations would suggest that what unfolds is likely to be due to a complex combination of history, chance, choice, interdependency and context.

So what does complexity theory have to offer social sciences? One of its most important roles is that it offers a new ontological 'image', which has the potential to shift the dominant paradigm from that of the still-dominant mechanical world view towards a view of the world as interconnected: where variation cannot be ignored, where new eras and behaviours can emerge, where change is not predictable and understandable in simple single-dimension relationships. If we approached global warming from that complex perspective, for example, we would be more likely to emphasise that the process is not easily reversible, that the timing of any changes of behaviour have to happen sooner rather than later as the impact is not linear; that irreversible shifts into new eras where new factors emerge and others are destroyed, is both possible and likely.

There is a huge amount of interest in modelling social systems and different classes of model are based on disparate and distinct assumptions within the variety of approaches classed as complex systems thinking. Some focus on stationary states, some include noise and variation, some are agent-based, some include non-linearities but are closed systems. Evolutionary and complex economics have their own literature and approach; there are models of cities and of traffic, of strategy and policy development, of leadership. Mathematicians and physicists are increasingly becoming interested in such human problems. These models can be very helpful in exploring the range of multiple possible outcomes; they can show what sorts of possible scenarios could occur, suggest and point to what might form the basis of effective interventions and policies and behaviours. They can help interpret the past and help throw light on how things have emerged. However, human systems are made up of people and people make decisions for complex reasons; moreover, they learn, they interact and they live in complex environments which themselves are constantly changing.

So, in approaching such problems mathematically, how do you decide what to include and what to ignore - particularly as, when phase shifts occur, that which was unimportant can suddenly become critically important? How do you account for diversity and for shifting contexts? This problem is usually well understood by modellers, who are keenly aware of the limitations of their models and the tentativeness of their outcomes; the problem often lies with policy makers and a public who expect certainty from scientists and have little time for uncertainty and for qualitative descriptions of possible scenarios.

So, I would argue that complexity science has a great deal to offer the social sciences as a new ontology; seeing the world as connected, diverse and not entirely knowable can be more useful and helpful than an optimistic and often misleading assumption of certainty and predictability. Wishing does not make it so. Complexity science has a great deal to offer as a way of modelling systemic problems in the social world, provided policy makers understand that the map is not the territory and that such a map will be either fairly helpful or sometimes totally and wildly unhelpful.

But I would exhort social scientists who adopt complexity thinking to take the time to understand as fully as possible the derivation of the ideas and resist adopting a butterfly here and a power law there without being as clear as possible as to the underlying assumptions of the methods; otherwise strange attractors may emerge and tip over the edge of chaos!

Jean Boulton is a Fellow of the Institute of Physics. She is Visiting Fellow at Cranfield School of Management where she developed and led the teaching of complexity theory to MBA students for some years. She, together with Professor Peter Allen, is writing a book, 'Embracing Complexity', to be published in early 2011 by Oxford University Press.

Jean is also helping to organise a conference, 'Complexity Applied', in Cambridge on September 23rd sponsored by the Institute of Physics, Nonlinear and complex physics group, see item Upcoming events supported by the NCPG.

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